Letter from Marston Niles to Alexander Graham Bell, February 11, 1899

Dear Sir:

I was much interested in the observations which you made at the end of Mr Mauro's lecture on the Graphophone, and I regret that they were not taken down in full by the reporters. I hope that it may be agreeable to you to communicate them in full detail to the public, through the press. It is difficult to give them the study which they deserve, if one must rely upon his memory: one should have the text before his eyes.

Those who are well acquainted with the principles and working of the graphophone might, I think, do a great service to the public by contriving a modification of it which would reproduce sounds like those of the voice on a vastly magnified scale. Doubtless there would be many uses for such an apparatus, but perhaps the greatest use would be found in the making of sound-signals at sea in fog, at night, etc.. It would prevent many collis s s ions. Unless I greatly mistake, it would be easy of construction, and would be able to send with distinctness vocal language to a distance of several miles. The present sound-signals are very limited in number, and the chairman of the committee dealing with that subject at the International Marine Conference at Washington, declared that his committee had gone “to their wits' end” in devising signals. The list, for practical purposes, ought to be fifty times larger than it is. Some years ago I sent a letter to Mr Edison, taking the liberty to suggest a method by which an intensification in his phonograph might be effected, but I did not receive any reply.

The phenomena produced in water when traversed by vessels at a very high speed, throw, I think, some light upon the causes of the difference in effect brought about by trebling the speed of the graphophone cylinder — causes which at Mr Mauro's lecture I understood to be regarded as still somewhat obscure. Since these phenomena are hardly known, or

perhaps I ought to say are hardly realized, except by those who have experimented with models etc., it may perhaps be of interest to you if I should refer to them briefly.

Extraordinary as it may seem, water is sufficiently viscous for it, when encountered by a ship-shaped body at a very high speed near the surface of the water, to assume, in certain situations, some of the properties of wax, soap, etc., or properties much resembling those. Under these circumstances it sometimes comes about that rapidity of penetration causes an increase of resistance to the motion of the body , in a most extraordinary ratio, perhaps not falling short of the fourth power of the rapidity. There is, of course, under all circumstances a vast difference between the behavior of particles of water, and that of particles of wax; but with the latter the increase of resistance to penetration must take place in a still higher ratio.

(over)

Each penetration of the stylus would seem of necessity to be accompanied by reäctions analogous to those occurring in the upper strata of water under the circumstances mentioned.

Were the stylus a very thin and very sharp chisel, and, did it point and move, under the influence of the compressed half of the sound-wave, in the direction of the cylinder-centre, and did it scrape away with its broadside (as of course would be impracticable) the wax in which it was partly imbedded and which the revolving of the cylinder brought constantly up against that advancing broadside, this chisel would still, in the centre-seeking and wave-produced element of its motion, be creating at its bows — if I may borrow the word for this purpose — a good- sized area of disturbance among those particles which would be lying immediately in front of, and to each side of , “its bows” — a disturbance, however, which (otherwise than as in water) would result partly in compression of the wax. The reäction from this disturbanc e would be in the nature of resistance to the centre-seeking component of the motion of the stylus, that is to say, of resistance to the expansion of the

compressed half of the sound-wave; and, in the reproduction of the sound, would have a damping effect, not only in respect to the descending, but also to the ascending, motion of the stylus; because this resistance would throw forward into the rarefield half of the sound-wave some of the thus hoarded energy of the compressed half, and thus would somewhat assimilate the status of the two halves of the sound-wave, reducing thus the amplitude of the vibration, and weakening (in the ratio of the square) the intensity of the sound produced from the swells and swales of the furrow.

Now with the stylus pointing away from the centre of the cylinder, in a direction nearer to that of parallelism with a tangent to the cylinder's surface, as is the case with the graphophone stylus, there is, in respect to its centre-seeking or wave-produced element of motion, a great of “bluffness of bow”, as compared with the sharpness of a chisel and the thinness of a chisel; and this bluffness greatly broadens the area of disturbance among the particles in front of it and at the sides of it , during the existence of a centre-seeking component in its motion; and the resistance to the centre-seeking component becomes a very considerable one, particularly so near the end of the downward movement, near which end the force of the sound-wave is at the least and lowest yet the packing or compression of the wax is at that instant (by virtue of the accumulation of compressive effects) at the greatest; hence, unless a remedy is provi ded , the stylus can hardly be expected to cut to its proper depth the lowest part of the furrow, but will come short of that, and, the cylinder motion continuing, will leap directly across and begin to rise.

The rapid cylinder appears to supply the remedy, in spite of the fact that the centre-seeking component of its motion, during a given instant of time, is doubtless greater than is the 2 case with the slow cylinder. The rapid cylinder develops a most important difference, namely, that while the area of disturbance (and consequent resistance to centre-seeking motion) among the particles of wax constitutes a layer of vexed particles which is three times as long as with the slow cylinder, it is a layer which is only one third as thick. The stylus annoys, let us say, quite as many particles as with the slow cylinder; but it annoys them in quite a different fashion. It attacks, we will say, as many clusters

of particles as does the slow cylinder; but it attacks three clusters strictly in succession, instead of attacking, as does the slow cylinder, a cluster indeed single but having behind it at that very instant two other clusters to back it up and present combined and synchronous resistances to a force exerted during that instant only. With the rapid cylinder, it is a case of divide et impera.

If the analogy between ship resistance and stylus resistance does to some extent exist — and my own mind, at any rate, would have to be made over again in order for me to believe that it does not exist — it is probable that the resistance to the down motion of the stylus does, at certain phases, increase in a ratio perhaps greater than the fourth power, as the depth of penetration increases. The relief which the rapid cylinder brings, lies in substituting fresh particles to be successively disturbed and compressed, with a disturbance and compression reckonable approximately in arithmetical ratio, for a deep column of particles to be all at once disturbed and compressed, with a disturbance and compression reckonable in geometrical ratio. If the sound-reproducing qualities of the slow cylinder do not show so great an inferiority as the very great difference just mentioned would seem to call for, this can properly be regarded as only a confirmation of the very natural suspicion that the most prominent difficulty which the graphophone must contend with, in advancing toward perfection, does not consist in the mere quantity of resistance to the centre-seeking motion of the stylus, but rather in the distribution of that resistance, and in the application of that resistance to the quelling and levelling-off of those slight inequalities in rate of downward speed, which inequalities inequalities would exist with the ideal stylus motion, and which would presumably, if they could be preserved, effect a perfect reproduction of the various checks, slurs, rumbles etc. of the various consonants and vowels, as well as a perfect reproduction of the timbre .

With the rapid cylinder, in its down furrow when considered as a whole , there is a further reduction of the area of centre-ward disturbance, in that the area of that disturbance is reduced in breadth in addition to depth; and this reduction must be considerable, because

the differences in the lengths of the chords of very small arcs are much greater than are the differences in the lengths of the chords of large arcs.

In making the down slope of the furrow considered as a whole, there is a further like reduction of the area of the said disturbance; which reduction takes place in the length of it, that is to say, in tangential direction.

If the analogy between ship resistance and stylus resistance exists, there are, in the rapid cylinder and in other forms of stylus points, several further and perhaps more important advantages traceable to similar causes, some of which relate to intensity, some to distinctness, and some to timbre.

It might be thought (and Mr Mauro's language perhaps suggests) that the supposed increasing of work — an increase by lengthening the furrow — in the rapid cylinder , — should be expected to result in damping the reproduced sound. I think it should be remembered, however, that this added burden of labor falls almost altogether upon the machinery for revolving the cylinder, and falls upon the sound waves only to that very trifling extent which is suggested by certain phenomena in ship model experiments.

You may perhaps pardon the length of this communication, if you bear in mind the general interest felt in the results achieved by the rapid cylinder. If my conceptions are in error, you may probably remember that an erroneous theory, if accompanied with a minute survey of facts , may sometimes be of service in provoking a conception in opposition and therefore nearer the truth.

If by any possibility observations and experiments of mine with water, bearing upon its visco u sity, could prove serviceable to any who may become interested in designing an apparatus in the nature of a Stentor , it would be a pleasure to me to contribute whatever assistance I could, and to do so either for the benefit of the public solely or also for joint benefit through a patent, just as they might prefer.

I am, Sir, yours truly Marston Niles Army and Navy Club, Washington, February 11th 1899. Prof. Alexander Graham Bell, 1331 Conn. Avenue, Washington.